1,152,434

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,152,434

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COMPLETE SPECIFICATION

Improvements in End Fittings For Rods

We, BRITISH INSULATED CALLENDER'S CABLES LIMITED, a British Company, of 21 Bloomsbury Street, London, W.C.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fittings, for applying a longitudinal tensile load to a fibre rod, of the kind hereinafter referred to as the kind specified, comprising inner and outer member adapted to move relatively to each other one within the other in the direction of the rod axis to prestress the material of the rod laterally, directly or indirectly, by a wedging action, the outer member having a tapered bore through at least part of which the rod passes. Fittings of this kind are wedge fittings and collet fittings. In wedge fittings of this kind, the end of the rod is inserted into the tapered bore and is secured in the bore by expanding the end of the rod by the insertion of a wedge or wedges into one or more than one slot or aperture in the end of the rod. In collet fittings of this kind, a part of the rod of uniform cross-sectional dimensions throughout its length passes through the tapered bore and is secured in the bore by compressing the rod by insertion of a sleeve of wedge-shaped cross-section into a space between the bore and the surface of part of the rod within the bore.

The term "fibre rod" as used herein means a rod made from fibres of high tensile strength bonded together to form a solid material in such a way that all of or a substantial proportion of the fibres are longitudinally disposed in the rod. The word "rod" is used in its widest sense. including solid or hollow elongated members suitable for use in tension. Although the fibres may be bonded by self adhesion, the invention is especially concerned with rods in which the fibres, which are for example glass fibres, are bonded by a synthetic resin.

An object of the invention is to increase the strength of the coupling between the rod and the fitting and in accordance with the invention this object is attained in a fitting of the kind specified by so shaping that part of the bore of the outer member of the fitting through which the rod passes that over a major portion of that part of its length the wall of the bore over at least part of the circumference of the bore lies at an angle, with respect to the axis of the bore, which progressively increases gradually, either continuously or intermittently, whereby the lateral pre-stressing of the material of the rod increases longitudinally from the part of the rod to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

In wedge fittings, the wedge or each wedge by which the rod is expanded in the bore preferably has at least one surface shaped to correspond to said shaped part of the bore but this is not essnetial provided that the outer surface of the rod is securely held against said part of the bore.

In collet fittings, that surface of the collet which makes contact with the tapered surface of the bore is correspondingly shaped. The bore of the collet will usually be a close fit on the rod and the wall of the collet may be formed with one or more longitudinal slits extending over the entire or greater part of its length.

The invention includes fittings for rods having bores shaped in this way, wedges and collets correspondingly shaped for use in such fittings, rods coupled to such fittings,

[Price 4s. 6d.]

and tension insulators comprising fibre rods coupled to the fittings.

When a fibre rod is split (into any number of segments) and expanded by the insertion of a wedge or wedges into the slot or slots in the rod, a residual tension and corresponding compression stress is put onto the rod by the consequent bending. These stresses are additional to the load that the rod may be carrying as part of its designed duty. Thus the load that can be carried is decreased in proportion to the bending produced by the wedge. This imposes a limit on the angle of the bore taper of a wedge fitting to about 10° inclusive angle for any reasonable load carrying to be achieved.

Similarly, when a fibre rod is compressed by the insertion of a collet into a tapered bore into which the rod passes, the compression stress put onto the rod is additional to the load that the rod may be carrying as part of its designed duty. Thus the load that can be carried is decreased in proportion to the compression stress produced by the collet. This imposes a limit on the angle of the bore taper of a collet fitting to about 15° inclusive angle for any reasonable load carrying to be achieved.

At the point where the expansion of the rod by the wedge or its compression by the collet commences, the tensile load carried by the rod could equal the ultimate tensile strength divided by the factor of safety but, because of the friction of adhesion between the rod and the fitting, some of this load will be transferred to the walls of the bore, directly in a wedge fitting or via the collet in a collet fitting, so that after each increment length ds from this point the load being carried by the rod is the load stress minus the load transferred to the fitting.

Consider now the load at the end of the first increment ds. At this stage, in the wedge fitting, the normal wedge action starts to occur and a slight bend may be introduced whereby an increased load will be transferred to the fitting over an increment ds adjacent to the first. Similarly, in a collet fitting a slight increase in compressive force is introduced whereby an increased load will be transferred to the fitting. If, in accordance with the invention, a bore of progressively increasing taper is used whereby over each subsequent increment ds a further bend or increase of compressive force is introduced, the rate of change of taper can be so chosen that at any point along the expanded or compressed part of the rod the residue of the load stress that the rod is designed to carry plus the tensile stress due to bending or compression equals the ultimate tensile stress divided by the factor of safety. The solution of a formula based on this relationship will give an ideal curve of bore taper.

From the above discussion it will be appreciated that it is preferable that the bore shape should conform substantially to such an ideal curve obtained by calculation, for example by the use of a digital computer programme, but that an advantage will be obtained over fittings having a uniformly tapering bore by any gradual progressive increase of an angle that the bore wall makes with the axis over a major portion of that part of the bore length through which the rod passes, the increase taking place in a direction such that the lateral pre-stressing of the rod increases longitudinally from the part to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

Although a continuous progressive increase of the bore angle is preferable, a significant improvement over a constant angle bore can be obtained when the bore angle increases intermittently to form, for example, a bore consisting of two or more frusto conical sections of increasing angle. Thus, in a wedge fitting, a bore consisting of two frusto conical sections of angle 3° and 6° respectively is better than a conical bore of angle $4\frac{1}{2}$°, these angles being the angle between the bore wall and the axis of the bore. Similarly, a collet consisting of three frusto conical sections of angle 1°, 3° and 7° respectively is better than a conical collet of uniform angle, each angle being the angle between a part of the outer surface of the collet and the axis of its bore, it being understood that the bore into which the collet fits will be correspondingly shaped. Deviations may be made from an exact correspondence in shape between the tapered bore in the fitting and the tapered surface of the collet to allow for such factors as the distortion in shape of the parts that may occur during use.

A further possibility is to use a bore with a progressively increasing angle of taper over a first major part of its length only, followed by a reducing angle of taper over a second part of its length, preferably the remainder of its length. In accordance with a further feature of the invention, in the second part, the angle which the wall of the bore makes with a co-axial cylindrical plane, tangential to the wall of the bore at the line of intersection of the cylindrical plane with the plane of maximum cross-sectional area of the bore, increases progressively over at least part of the circumference of the bore wall. The fitting preferably comprises a further outer member having a progressively decreasing bore size that is fitted on to the rod after the wedge has been inserted or the collet fitted onto the rod and which is provided with means

whereby it can be drawn axially towards the said outer member to grip the slit rod between the wedge and the bore or to compress the rod by means of the collet. The wedge is preferably in this case shaped to correspond the bore shape.

Examples of wedge and collet fittings in accordance with the invention will now be described with reference to the accompanying drawing in which

Figures 1 to 3 are sectional elevations of wedge fittings and

Figure 4 is a sectional elevation of a collet fitting.

The simplest form of wedge connection for a solid rod of circular, rectangular or other cross-section consists of a single wedge inserted into a single slot, preferably in a plane containing the axis of the rod. Similarly, the simplest shape for the bore into which the rod is expanded is a bore having a cross-sectional shape similar to that of the rod but of progressively increasing size towards the part of the bore to be occupied by the end of the rod.

Figures 1 and 2 show fittings of this type. Referring to Figure 1, the rod 1 is of circular cross-section and is inserted into a tapered bore of circular cross-section in a ferrule 2. A single slit is made in the end of the rod in a diametric plane (perpendicular to the plane of the paper) and a wedge 3, of uniform cross-section in the plane of the paper and of a width (measured perpendicularly to the plane of the paper) equal to the diameter of the rod before expansion, is forced into the slit. The curved faces of the wedge each have a shape identical with that of the bore (taken in a diametric plane).

The fitting shown in Figure 2 is similar to that shown in Figure 1 except that the angle of taper of the bore and of the wedge 3 increases intermittently in three stages 4, 5 and 6.

Although it is preferable to use a wedge or wedges having an angle of taper corresponding to that of the bore, this is not essential provided that the wedge or wedges used, alone or in combination with filling material introduced into the slot or slots or aperture or apertures in the rod with the wedge or wedges, securely holds the outer surface of the rod against the bore surface over a sufficient length of the bore to enable the required load stress to be accepted. A fitting in which the wedge 3 has a uniform angle of taper is shown in Figure 3. The rod 1 is of resin bonded glass fibre and the suitable filling material 7 is of the same or a similar resin to that used for bonding the glass fibre, made up as a dough with chopped glass fibre.

Since when a rod of circular cross-section is formed with a single slot to receive a single wedge, the maximum pressure between the surface of the rod and the surface of the bore can only be generated over limited parts of the circumference of the bore, these parts of the circumference only need be shaped to fit the rod, that is to say, the cross-section of the expanded part of the bore can have straight sides at right angles to the median plane of the wedge joined by arcuate, preferably semi-circular, parts against which the split rod is pressed by the wedge. The length of the straight sides will then progressively increase and remain substantially equal to the thickness of the contiguous part of the wedge.

Alternatively, for a rod of circular cross-section a conical or concave conoidal wedge can be used which is either inserted into a blind bore formed in the end of the rod (either a straight sided or a tapered bore) or is inserted into the intersections on the axis of the rod, of two diametrical slits at right angles to each other. Similarly, when the rod is in the form of a tube a conical or concave conoidal wedge can be used.

As already indicated, more than one wedge can be used, if desired, to expand the split or apertured rod into contact with the wall or walls of the bore.

In the collet fitting shown in Figure 4 the collet 8 is of circular cross-section and, in accordance with normal practice, is provided with two opposed longitudinal slits 9. Alternatively, there may be a single longitudinal slit extending the whole length of the collet or there may be two or more such slits completely dividing longitudinally into two or more parts. The use of a multi-part collet, formed in effect from a number of planar wedges, is preferred when the rod is of rectangular cross-section.

The smaller end 10 of the collet 8 is of uniform wall thickness and of an external diameter substantially equal to the smallest diameter of the tapered part and the slits 9 in the collet wall terminate in this part of uniform wall thickness. They may alternatively terminate at the junction between this part and the part with a tapered outer surface. A short length of a part 11 of the collet of uniform wall thickness projects from the bore in a ferrule 12 in which the collet is accepted.

In the fitting shown in the drawing the collet is initially forced into the bore until it is a sufficiently tight fit on the rod 1 to ensure that it is automatically drawn into the tapered bore in the fitting when a load is applied to the rod and increases its grip on the rod as the tensile load applied to the rod increases. In accordance with normal practice, auxiliary means may be provided for drawing or forcing the collet into the tapered bore to cause it to grip the rod. For example a part of the smaller end of

the collet, preferably a part of uniform wall thickness, may be formed with an external thread on which a nut engaging the corresponding end of the fitting runs, or a compression nut running on a suitable thread on or in the fitting may engage the larger end of the collet to force the collet into the tapered bore.

The collet fitting in accordance with the invention is suitable for attachment either at or near an end of the rod or at an intermediate point on the rod. It will always be arranged on the rod in such a way that the direction of increase of taper is opposite to the direction in which the load will be applied to the rod, so that increased loading of the rod increases the compressive force applied by the collet to the rod.

The simplest form of collet fitting for a solid rod of circular cross-section consists of an inner, collet, member in the form of externally tapered sleeve of circular cross-section with a parallel bore which fits into the rod and an outer member with a bore shaped to accept the tapered surface of the collet, both of the tapering surfaces having continuously or intermittently increasing taper angle. However, since for a rod of non-circular cross-section the maximum pressure between the surface of the rod and the surface of the bore in the collet can only be generated over limited parts of the circumference of the bore, the corresponding parts of the circumference of the tapered surface only need have a progressive increase in taper angle.

The outer member of the fitting will normally be a ferrule by which the rod is to be attached to another structural member but it will be appreciated that the bore can be formed directly in the structural member to which the rod is to be attached. A tension insulator in accordance with the invention may for example consist of a resin bonded fibre rod having attached to each end a metal ferrule with a bore shaped as described above. The rod is preferably of the kind made by drawing glass fibres through a resin and a suitable forming die and subsequently curing the resin. The ferrules may be adapted for connection to supports for the insulator or may form part of such end supports.

WHAT WE CLAIM IS:—

1. A fitting of the kind specified for applying a longitudinal tensile load to a fibre rod wherein that part of the bore of the outer member of the fitting through which the rod passes is so shaped that over a major portion of that part of its length the wall of the bore over at least part of the circumference of the bore lies at an angle with respect to the axis of the bore, which progressively increases gradually, either continuously or intermittently, whereby the lateral pre-stressing of the material of the rod increases longitudinally from the part of the rod to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

2. A wedge fitting for applying a longitudinal tensile load to a fibre rod comprising a member having a bore through at least part of the length of which the rod passes, said members being so shaped that over a major portion of that part of its length the wall of the bore over at least part of the circumference of the bore lies at an angle with respect to the axis of the bore, which progressively increases gradually, either continuously or intermittently, and a wedge or wedges for insertion into one or more than one slot or aperture in the end of the rod to expand the rod and cause the material of the rod to be pre-stressed between the wedge or wedges and the wall of said portion of the bore, whereby the lateral pre-stressing of the material of the rod increases longitudinally from the part of the rod to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

3. A wedge fitting as claimed in Claim 2 in which the or each wedge has at least one surface shaped to correspond to said portion of the bore.

4. A wedge fitting as claimed in Claim 2 in which the or each wedge has a uniform angle of taper.

5. A collet fitting for applying a longitudinal tensile load to a fibre rod comprising a member having a bore through at least part of the length of which the rod passes, said member being so shaped that over a major portion of that part of its length the wall of the bore over at least part of the circumference of the bore lies at an angle, with respect to the axis of the bore, which progressively increases gradually, either continuously or intermittently, and a sleeve having at least part of its outer surface shaped to correspond to the shape of said portion of the bore for insertion into a space between the wall of said portion of the bore and the surface of part of the rod within the bore, whereby the lateral pre-stressing of the material of the rod increases longitudinally from the part of the rod to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

6. A collet fitting as claimed in Claim 5 in which the sleeve is longitudinally slotted over the greater part of its length.

7. A collet fitting as claimed in Claim 5 in which the sleeve is longitudinally divided into two or more parts.

8. A collet fitting as claimed in Claim 5 in which the sleeve has a part of uniform external diameter, substantially equal to

the smallest diameter of the tapered part, at least a portion of which fits into a part of the bore which is also of uniform diameter.

9. A fitting as claimed in any preceding Claim in which the bore has a progressively increasing angle of taper over a first part only of its length, followed by a reducing angle of taper over a second part of its length.

10. A fitting as claimed in Claim 9 in which in said second part the angle which the wall of the bore makes with a co-axial cylindrical plane tangential to the wall of the bore at the line of intersection of the cylindrical plane with the plane of maximum cross-sectional area of the bore increases progressively over at least part of the circumference of the bore wall.

11. A fitting as claimed in Claim 10 comprising a further outer member having a progressively decreasing bore size and means for drawing said further outer member axially towards said outer member.

12. A method of attaching to a fibre rod a fitting for applying a longitudinal tensile load to the rod which comprises laterally pre-stressing the material of the rod directly or indirectly by a member of the fitting having a bore through at least part of the length of which the rod passes so shaped that over a major portion of that part the wall of the bore over at least part of the circumference of the bore lies at an angle, with respect to the axis of the bore, which progressively increases gradually, either continuously or intermittently, whereby the lateral pre-stressing of the material of the rod increases longitudinally from the part of the rod to be subjected to the maximum longitudinal load towards the part to be subjected to the minimum longitudinal load.

13. A method as claimed in Claim 12 in which an end of the rod is expanded by the insertion of a wedge or wedges into one or more than one slot or aperture in the end of the rod to cause the material of the rod to be pre-stressed between the wedge or wedges and the wall of the bore.

14. A method as claimed in Claim 12 in which a sleeve having at least part of its outer surface shaped to correspond to the shape of said portion of the bore is inserted into a space between the wall of the bore and the surface of part of the rod within the bore to cause the material of the rod within the sleeve to be laterally pre-stressed.

15. A method as claimed in Claim 12 applied to a fitting as claimed in any of Claims 3, 4 and 6 to 11.

16. A method as claimed in Claim 13 in which the tapering surfaces of the or each wedge do not correspond in shape to that of the bore and in which the space or spaces between each wedge and a slot or aperture in the rod in which the wedge is fitted is or are filled with a filling material.

17. A method as claimed in Claim 16 in which the rod is a resin bonded glass fibre rod and the filling material is based on a resin which is the same as or similar to that used for bonding the glass fibres in the rod.

18. A fibre rod having attached thereto a fitting as claimed in any one of Claims 1-11 by a method as claimed in any one of Claims 12-17.

19. An electric insulator comprising at least one resin bonded glass fibre rod having attached thereto a fitting as claimed in any one of Claims 1-11 by a method as claimed in any one of Claims 12-17.

20. A fibre rod having a fitting attached thereto substantially as hereinbefore described with reference to and as shown in Figures 1, 2, 3 or 4 of the accompanying drawing.

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1,152,434 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig.1.

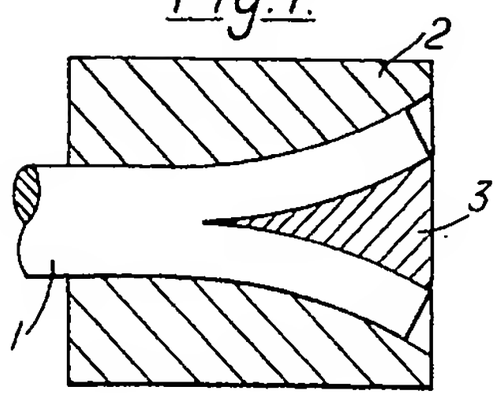

Fig.2.

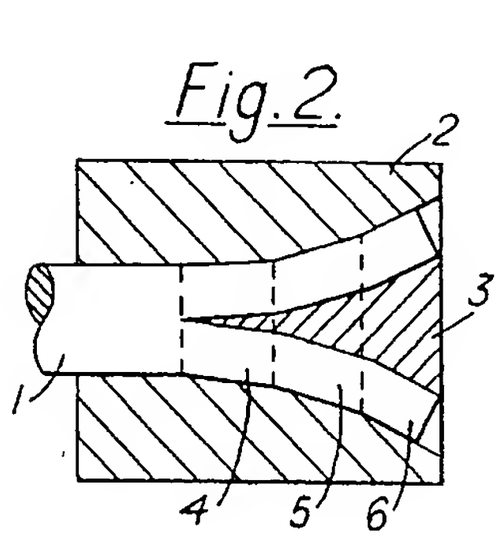

Fig.3.

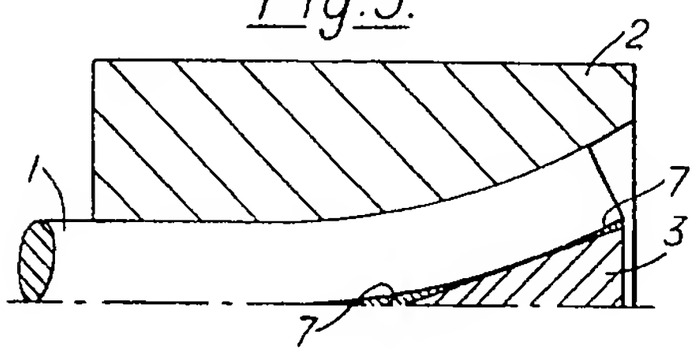

Fig.4.